

- Fig. 16.* The same. Permian. Celluliferous face, worn; magnified 12 times. Tunstall Hill.
- Fig. 17.* The same. Permian. Celluliferous face, unabraded; magnified 12 times. Tunstall Hill.
- Fig. 15.* The same (*Fenestella plebeia*, M'Coy). Carboniferous. Non-celluliferous face; magnified 6 times. Beith.
- Figs. 14, 18.* The same. Carboniferous. Celluliferous face, worn; magnified 12 times. Beith.

[Carboniferous specimens marked C; Permian specimens marked P.]

XXII.—On *Synapta digitata* and its supposed Parasite.

By A. BAUR*.

I. *The attachment of the Molluskigerous Sac to the head of the Synapta.*

THE point the elucidation of which is of most importance with regard to the relation of the sac-producing Mollusca to the Holothurid is the case, once seen by J. Müller, in which three molluskigerous sacs were attached within the head of the *Synapta*. J. Müller remained in doubt as to the meaning of this attachment, the mode of adhesion, and the nature of the outer extremity of the sac; he considered further observations upon the constancy or inconstancy of the attachment to the head to be necessary†.

Captures of *Synapta digitata*, continued during three months, furnished me repeatedly with molluskigerous sacs thus attached. It was also possible to examine more closely the mode of attachment, and to settle by observation the question whether it was constant or inconstant, whether it was accidental or connected with the origin of the molluskigerous sac, or perhaps with the immigration of the molluskigerous parasite.

While among 100–200 individuals of *Synapta digitata* it is not easy to find more than one infested by a molluskigerous sac, or now and then by several, there were three out of 120–130 *Synapta* containing molluskigerous sacs, in which the sac, besides being attached as usual to the intestinal vessel, at the same time turned its ordinarily free and posteriorly directed end towards the head of the *Synapta*, and was attached there likewise. In all the three cases the sac attached to the head was of the same nature; it differed, also, in no essential point from the others, which in other individuals extended freely backward into the body-cavity of the *Synapta*. None of the three mollus-

* Translated by W. S. Dallas, F.L.S., from the Monatsbericht der Akad. der Wiss. zu Berlin, April 1862, p. 187.

† J. Müller, "Ueber *Synapta digitata* und über die Erzeugung von Schnecken in Holothurien," p. 15. (See 'Annals,' February 1852, p. 106.)

kigerous sacs were smaller, but they were rather amongst the largest observed; they were all sexually mature, and contained either ready-formed mollusks or ova in course of development into mollusks. None of the three cases furnished any support for the supposed possibility that the sacs attached to the head of the *Synapta* might be an earlier stage.

The connexion of the extremity of the sac with the head of the *Synapta*, when it exists, is very intimate. The terminal portion of the molluskigerous sac, when forcibly pulled, is torn before the adhesion will yield. This firmness is not due to any coalescence; its cause is mechanical, and depends upon an interlocking. The terminal portion of the molluskigerous tube was in all three cases wrapped together into the form of a coil—as it were, stuffed into a space enlarged by stretching, and held firmly therein by a narrow constricting portion. After the careful separation of the constricting parts in the head of the *Synapta*, the end of the sac could be completely unfolded and prepared in an uninjured state, with the exception of the loss by stripping off of the outermost layer of cells. The point of attachment always corresponds externally to a spot of the circumference of the oral or cephalic disk, where it borders on the base of the tentacles. The point of attachment is not constant upon this circumference; it is sometimes on one side and sometimes on the other of the median line indicated by the mesentery and sexual orifice. In two of the observed cases a yellow swelling, caused by the more intensely coloured molluskigerous sac shining through it, could be detected even from the outside in the still uninjured and living head of the *Synapta* within the circle of tentacles. The body-wall of the *Synapta* was, however, not perforated; the end of the sac was not bare, but was always distinctly covered, at least, by the outermost reddish layer of the body-wall (epidermis and dermis of Quatrefages). In one case the most careful examination showed that internally the coil-like end of the molluskigerous sac had filled and considerably distended the base of two neighbouring tentacular cavities. These remained distinctly enlarged even after the separation and removal of the coil. In the two other cases the end of the sac had not occupied the cavity of the water-vascular system at its entrance into the tentacles, but the space close by, between the buccal disk, calcareous ring, and œsophagus, and therefore between the canals passing from the annular canal to the tentacles.

The condition described, especially in the first case, in which the entrance into two tentacles was evidently forcibly dilated, admits only of one explanation. The adhesion of the sac to the head can be effected only in the following way:—whilst it usually

extends backward in the body-cavity of the *Synapta*, in this case it turns forward towards the head, its extremity is forced, at any spot offering the least resistance, between the parts there existing, and under certain circumstances into the canals, where it is firmly held, like a portion of intestine wedged into a diverticulum of the ventral cavity: such a spot is presented by the tentacular cavities, if we leave out of consideration the delicate and but slightly resistant walls of the aquiferous vessels, by which the tentacular cavities are separated from the body-cavity of the *Synapta*.

When disquieted or irritated, the *Synapta*, or each fragment having a head, endeavours to break itself to pieces. Before this is effected at any definite spot, the worm-like body performs powerful alternate contractions and extensions. The pressure exerted by the muscular body-wall upon its contents is so strong that, at the moment when the wall bursts, the fluid of the body-cavity often spirts out in a stream. At the same time it frequently happens that with the first rupture of the body-wall the intestine, together with the genital tubes, is forcibly driven out laterally. In the same way the molluskigerous sac, with its free end turned towards the head, may be firmly held by a constriction in the neighbourhood of the calcareous ring, where a rupture never takes place. The attenuation which, according to J. Müller, the sac exhibits towards its extremity is explained by the dragging and stretching necessarily accompanying this process.

As appears from the nature of the *Synapta*, as well as from that of the extremity of the sac, the mode of attachment is purely mechanical; it does not consist in an organic connexion of the sac with the head of the *Synapta*. In the effectuation of the cephalic attachment the molluskigerous sac is purely passive: the effective cause is the pressure exerted by the contractile wall of the body of the *Synapta* upon its contents, and consequently also upon the molluskigerous sac.

The cephalic adhesion is, finally, inconstant, and purely accidental, because it is to be ascribed to an accidental vital manifestation, or perhaps more correctly to a phenomenon of the agony of the *Synapta*—a convulsive contraction of the body, perhaps produced only by capture or by violent injury.

The notion that we are to regard the molluskigerous sac, when attached to the head of the *Synapta*, as not organically united, but perhaps as a parasite breaking through the body-wall of the *Synapta* either in immigration or emigration, and the adhesion itself as a transitory act of the molluskigerous sac which, for this reason, so rarely comes under observation, is got rid of by what has been said above. But still there is one cir-

cumstance to be considered, which has been referred to this very point.

In one case described by J. Müller, which, among the rare cases of cephalic attachment of the molluskigerous sac, was itself a rare exceptional case, inasmuch as three sacs were present in one *Synapta*, and all three of them were attached to the head, one of the sacs, and this the smallest and shortest, although otherwise not different, and still uninjured, had the extremity usually affixed to the intestinal vessel free in the cavity of the body. J. Müller was inclined to attach much importance to this circumstance in the interpretation of the sacs as parasitic creatures. The mode in which this might happen has been elucidated by the anonymous reporter in the 'Annals of Natural History,' January and February 1852, by reference to the penetration of the Cercariæ into the skins of the Mollusca. J. Müller himself has left it uncertain whether this third sac, with a reversed attachment (that is to say, attached by the usually free extremity, and free at that which is usually attached), was still very young and undeveloped, or whether its development and generation were completed, and itself in course of retrograde metamorphosis,—whether it would attain its position on the intestine only by further growth, or whether the union had previously occurred at the ordinary place, but been dissolved by the gradual reduction of the sac. The reporter in the 'Annals of Natural History' regarded it as an ascertained fact, from J. Müller's observation, that the sac is at first attached only to the body-wall of the *Synapta* (at the head), and subsequently to the intestinal vessel.

The behaviour of the molluskigerous sacs as they occur in the cavity of the body of the *Synapta*, especially when the cephalic attachment is left out of the question, forbids our connecting this circumstance with evolution, whether progressive or retrograde, or with the immigration of the molluskigerous sac. It is quite an ordinary phenomenon to find in the cavity of the *Synapta* perfectly free, floating molluskigerous sacs, which have evidently been torn from the intestinal vessel only by the capture and the violent movements of the *Synapta* accompanying it. But if a molluskigerous sac be completely attached to the head, the freedom of the other extremity is still less remarkable. As it may be proved from the cephalic attachment itself that in this case a force has been exerted upon it which pressed it against the head of the *Synapta*, and even wedged it into that part, it is not to be wondered at if the same pressure which, in the case of J. Müller, drove these sacs towards the head, should have separated one of them from its position on the intestinal vessel. Nor is it surprising that this should apply to the

smallest specimen—to that whose length is less than the distance of the ordinary point of attachment on the intestine from the head of the *Synapta*, as may be seen from the figure (tab. 2. fig. 3) given by J. Müller. Therefore, as the abnormal attachment to the head is nothing but a mechanical and accidental engagement of one end of the sac, so the simultaneous absence of the normal adhesion in the one case observed by J. Müller is merely a mechanical separation of the other end from the intestinal vessel, referable to the same accidental cause. Neither the one nor the other stands in any nearer relation to the growth, development, or vital history of the molluskigerous sac.

II. On the adhesion of the Molluskigerous Sac to the Intestine.

In the natural state we are never to imagine the molluskigerous sac in the *Synapta* otherwise than as attached by one end, in the manner described and figured by J. Müller, to the intestinal vessel opposite to the mesentery, with the other end extending freely backwards in the cavity of the body along the intestinal canal of the *Synapta*. If the sac be quite free, it has been accidentally separated; if it be attached by the free end to the head, it has been accidentally engaged there.

The natural adhesion of the molluskigerous sac is effected in this way: the button-like extremity, probably the buccal portion of the molluskigerous sac, projects into the lumen of the intestinal vessel through a slit in the wall of the latter, and is firmly held therein, exactly like a button in its button-hole. Behind the knob the wall of the vessel clasps the sac so closely, that a forcible separation is not possible without tearing away the button, or enlarging the slit, so that the sac may easily appear to have become organically united with the intestinal vessel. There is, however, no evidence of such a union; on the contrary, the simple engagement of the button is perfectly sufficient to explain the firmness of the connexion between the sac and the intestinal vessel.

The mode of attachment of the molluskigerous sac to the intestinal vessel is, therefore, like its adhesion to the head, *purely mechanical*, and depends no more than the latter upon an organic union. It is not, however, like this, accidental; on the contrary, this attachment is constant for the occurrence of every uninjured sac in the uninjured *Synapta*, and, which is the most remarkable, constant with regard to the spot on the intestinal vessel, although this extends, with the same diameter, and the same properties, and in the same position, along the whole intestine of the *Synapta*, from the stomach to the anus.

How this attachment is effected, that is to say, how the molluskigerous sac buttons itself into the intestinal vessel of the

Synapta, is the next question with which we have to deal. It cannot take place by the molluskigerous sac remaining passive, as in the cephalic attachment. The attachment to the intestinal vessel must, on the contrary, be an act in the life of the molluskigerous sac, an act, however, which is still entirely withdrawn from our inspection.

With regard to the development and early vital history of the molluskigerous sac, its occurrence in the full-grown *Synapta* furnishes no other information than is to be found in the observations of J. Müller. In the full-grown *Synapta*, the molluskigerous sac is never found, at any period of the year, otherwise than in the sexually mature and molluskigerous state, and attached in the manner above described.

III. *The young forms of Synapta digitata, Müll.*

Quatrefages, in his observations upon *Synapta Duvernæa* (Annales des Sciences Nat. 2 sér. 1842, p. 73), has pointed out that, much as these Holothuriæ might be observed on the shores of the Mediterranean and in the Atlantic, they are yet never met with otherwise than in a perfectly developed and sexually mature state, and not less than 6 inches in length. This applies also to *Synapta digitata*. The non-appearance of smaller specimens is explained by Quatrefages upon the well-founded supposition that these vermiform Echinoderms, in passing through a metamorphosis, will have a larval form, which, no doubt, will be quite different from that which they afterwards assume.

Among the numerous forms of swimming larvæ of Echinoderms discovered by J. Müller, are some whose metamorphosis could be traced into animals which, from their general anatomical characters, are Holothuriæ. These are the *Auriculariæ* remarkable for their singular form and compared to a rococo coat-of-arms (Abhandl. der Akad. der Wiss. 1848, p. 98; 1849, p. 35; and 1850, p. 37). Of these larvæ J. Müller has made known two different and apparently widely distributed forms; both were first observed at Marseilles in spring, then at Nice in August and September, and lastly at Trieste, one only in the spring, and the other late in the summer. Their external distinctions are, that one bears in the middle of the posterior extremity of the body a calcareous gland running out into radiate teeth—in fact, a calcareous star, and also, in the lobes into which the body of the larva is prolonged all round, a garniture of clear, pale-red spherules, not composed of lime; the other larva is destitute of these spherules, and has in the two lobes of the posterior end of the body which contains the anus, besides an inconstant calcareous sphere, a variable number of very regular calcareous wheels. The young Holothuriæ (still swimming by means of bands

of cilia) into which these larvæ are transformed coincide most in their anatomical structure with the footless and abbranchiate section to which the genera *Chirodota* and *Synapta* belong. They retain, in the skin at the posterior extremity of the body, the peculiar calcareous structures of the larva.

For the more precise determination of one of these larval forms, and the corresponding young Holothurid, with the globules and the calcareous star, J. Müller possessed no data (*loc. cit.* 1849, p. 55). In the other, the occurrence of the calcareous wheels still at the posterior extremity of the young Holothurid could not but lead to the supposition that it belonged to the genus *Chirodota* (*ibid.* p. 49), because this genus has calcareous wheels in the skin, whilst the nearly allied and anatomically accordant genus *Synapta* has little anchors inserted into a perforated calcareous plate.

Grube has described two Holothurids of the genus *Chirodota* from the Mediterranean — *Chirodota Chiaji* and *C. pinnata* ('Actinien, Echinodermen und Würmer des adriat. und Mittelmeers,' 1840). It has, however, been found that these two, from their zoological characters, namely, the calcareous armature, are not *Chirodotæ*, but *Synaptæ*, and that *Chirodota Chiaji*, Gr. (*Holothuria digitata*, Mont.), and *Chirodota pinnata*, Gr. (*Holothuria inhærens*, O. F. Müll.), must receive the generic name of *Synapta* (Müller, Archiv, 1850, pp. 115, 135, 136). One of them is Müller's *Synapta digitata*, and the other *Synapta inhærens*, the latter again being probably identical with *Synapta Duvernæ* of Quatrefages.

As no true *Chirodota*, no Holothurid with calcareous wheels, is yet known from the Mediterranean, there were two possibilities in regard to the origin of the *Auricularia* with calcareous wheels. Either it belonged to a true *Chirodota* peculiar to the Mediterranean, but still unobserved; or the calcareous wheels in the skin of the larva and young Holothurid could only be transitory structures, and other calcareous structures must subsequently make their appearance in them (Abh. der Akad. der Wiss. 1849, p. 50). The former was the less probable, because, from the abundance of the *Auricularia* with calcareous wheels, it could scarcely be supposed to belong to a still unknown and therefore certainly rare Holothurid; but in the latter case the abundant and widely distributed *Synaptæ* must be taken into consideration. The decision of the question depended on tracing the young Holothurids produced from the larvæ with calcareous wheels (which, in the latest stage seen by J. Müller, still moved by swimming with their bands of cilia) in their further growth and changes, but especially with respect to the appearance of calcareous structures in other parts of the skin.

Krohn has succeeded in keeping alive young Holothurids with calcareous wheels, taken in spring at Messina, until they lost the rows of cilia and crept in a perfectly worm-like manner, "like *Synapta*" (Muller's Archiv, 1853, p. 319). In one individual, moreover, Krohn saw the number of the still simple tentacles, which is originally five, increase to eight by the simultaneous growth of three new ones. In the discovery of this later stage, Krohn also thought he found a support for the opinion of J. Müller already referred to, namely, that the small *Holothuria* and *Auricularia* with calcareous wheels belong to the genus *Chirodota* [*Synapta*?—ED.].

Synapta digitata, as it occurs in the Bay of Muggia, near Trieste, reproduces in the spring (Leydig, in Müller's Archiv, 1852, pp. 507, 516), and, as I ascertained, only once in the year. I have observed that the appearance in great numbers of the *Auricularia* with calcareous wheels in the Bay of Muggia, where *Synapta digitata* lives in abundance on the sea-bottom, coincides exactly with the time at which the distended genital sacs of the *Synapta* contain mature ova with a germinal spot, and zoospermia, and that shortly afterwards they are all found empty.

I have also succeeded in tracing the development of the larvæ, pupæ, and young Holothurids (which are at first easily caught, but afterwards captured with gradually increasing difficulty) up to the point at which they live, in the form of small transparent worms of about 8 mill. in length, in the fine mud of the sea-bottom, and have gradually acquired all the anatomical and zoological characters of *Synapta digitata*. In the last observed and furthest advanced animals the number of tentacles, by a further pushing out of four new ones, had become twelve, the number occurring in the mature *Synapta*. The originally simple, conical tentacles had acquired the specific form of those of *Synapta digitata*; they terminated in five little feelers, arranged like fingers, of which the middle one was short and curved outwards. They had the suckers on the inside of the base, and performed movements from without inwards, accompanied by alternate extension and retraction. The skin, which was at first unarmed, had become beset all over with peculiar calcareous structures; these were little anchors, each attached moveably, by means of a knob, to a perforated calcareous plate. At the same time, however, the calcareous wheels present in the larva were still retained at the posterior extremity of the body; but their number had not increased.

From this it appears that the Auricularia with calcareous wheels is the larva of Synapta digitata, Müll., and that the Synapta has a young stage in which it has already attained its definitive form, and possesses the anchors in its skin, but still bears the wheels of the larva at its posterior extremity near the anus.

The methods by which I succeeded in rendering the young *Synapta* accessible to observation, the details of the developmental processes, so far as they have not already been observed by J. Müller, and the anatomical characters of *Synapta digitata* (visible with remarkable facility in the little transparent creatures, which are perfect from mouth to anus) shall be described in detail. At the same time reasons will be given why the unveiling the vital history of the molluskigerous sac is rendered probable by the discovery of these young *Synapta*. The difficulties which set bounds to the further prosecution of this course lie in the fact that it was not possible to capture *Synapta digitata* in the young state described in the same quantity as the full-grown animals, which is the first condition for the observation of the molluskigerous sac, on account of its great rarity.

Together with *Synapta digitata*, the somewhat smaller *Synapta inhærens* (probably *S. Duvernæa*, Quatref.), distinguished by its more strongly adhesive skin and plumosely branched tentacles, occurs in smaller numbers near Trieste, in the Bay of Muggia. I had the opportunity of observing the brood of this species also, mixed with that of *S. digitata*, up to the point at which it likewise had the anchors in its skin and acquired the full number and specific form of its tentacles. The young Holothurids of this species are only distinguished by having no calcareous wheels or globules in the posterior extremity, but, instead of them, a group of irregularly angular calcareous pieces. From the *Auricularia* of *Synapta digitata* that of *S. inhærens* probably does not differ at all, except in this condition of the calcareous structure. The latter would, therefore, not be recognized at the time when only larvæ, without any young Holothurids, occurred.

XXIII.—*On the Discovery of Ancient Remains of Emys lutaria in Norfolk.* By ALFRED NEWTON, M.A., F.L.S.

[Plates VI. & VII.]

ON the 31st of March last, in the course of a communication to the Philosophical Society of the University of Cambridge, I had the pleasure to announce a fact in British archæontology, which, as far as I am aware, is hitherto unrecorded; and as that paper will not be published in a form likely to bring it under the especial notice of naturalists, I propose to give a short account here of what I venture to think may be regarded as a discovery not altogether unimportant.

In the early part of this year, while examining a considerable collection of ancient remains in the possession of Mr. Birch, of